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ABSTRACT

It was hypothesized that high visual imagery is a liability during acquisition periods and an asset during consolidation periods of Piaget's stages of concrete and formal operations. It was also hypothesized that at all ages high imagery would be related to performance on a "spatial egocentrism" task. A sample consisting of 195 children from grades one, four, six and ten was drawn. Subjects were assessed for imagery level by the method used by Hollenberg, and on three Piagetian tasks. Results from correlations and analyses of covariance indicated that high imagery does not handicap operational thinking, that it may be facilitative during consolidation periods, and that it is associated with superior performances on spatial egocentrism tasks at all ages. Results also suggest that imagery may become increasingly salient for girls, and decreasingly salient for boys, as cognitive development proceeds. (Author/RH)

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Individual Differences in Visual Imagery and Piaget's Stages

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Running head: Visual Imagery and Piaget's Stages

Abstract

It was hypothesized that high visual imagery is a liability during acquisition periods and an asset during consolidation periods of Piaget's stages of concrete and formal operations. It was also hypothesized that at all ages high imagery would be related to performance on a "spatial egocentrism" task. A sample of 195 children from Grades One, Four, Six and Ten were assessed for imagery level by the method used by Hollenberg (1970), and on three Piaget tasks. Results from correlations and analyses of covariance indicated that high imagery does not handicap operational thinking and may be facilitative during consolidation periods, as well as on "spatial egocentrism" tasks during all periods.

Individual Differences in Visual Imagery and Piaget's Stages

The role of visual process in cognitive functioning has been accorded new importance in recent years, after several decades of neglect (Holt, 1964; Richardson, 1969). The emphasis on abstract and verbal process has been shifted and broadened to include consideration of other forms of cognition, including an active visual imagery, through which conceptualization and problem-solving can be facilitated.

Hebb (1969) suggested that spatial organization may have a unity and function of its own, similar to that of abstract cognitive process. This idea has been tested in a variety of settings. For example, Shepard and Metzler (1971) reported studies of spatial manipulation problems, in which latencies varied in such a way as to suggest that subjects actually "rotated" the stimuli mentally to arrive at solutions. De Soto, et al. (1968) and Huttenlocher (1968) demonstrated that spatial rules can sometimes be more adequate than grammatical or logical rules for explaining the order of difficulty among syllogism problems. Studies in verbal learning and memory have shown that visual imagery, rather than verbal mediators, often can account for significant differences in learning (Paivio, Smythe and Yuille, 1968; Kosslyn and Bower, 1974;

Lupiani, 1979).

Theories of cognitive development have tended to limit the importance of visual process to an early period of development, prior to the acquisition of verbal and other cognitive skills. Piaget and Inhelder (1969) differentiated between operative and figurative aspects of thinking, the former being active constructive processes, the latter including imagery and other derivatives of perception, "copies of reality" (p. 87). These authors considered the possible relationship between imagery and operations, but generally viewed visual process as static, passive and primarily preoperative. Bruner (1966) recognized that the ikonic mode operates throughout development, but he placed its important functioning in the preverbal period, and assumed that too much reliance on ikonic process can interfere with later cognitive development.

On the other hand, some studies (Rohwer, 1970; Spodak, 1972) have suggested that visual process, instead of becoming less important with age, may actually be of greater help in learning tasks after verbal mediation is established. The question, then, is whether visual imagery is an asset or a handicap in cognitive growth.

One approach to the question is to identify individuals who habitually use high levels of visual imagery, and compare their performance on cognitive tasks with that of individuals who do not

rely heavily on imagery. This individual difference, first proposed by Bartlett (1932), appears to be a stable one (Goldberg and Meredith, 1975). Hollenberg (1970) used this approach in a developmental study comparing "high imagers" with "low imagers" on a set of concept attainment tasks. Her results showed that for children under the age of nine, high imagery apparently interferes with concept attainment, thus supporting Bruner's view. The explanation was that high imagers are unable to break away from the perceptual aspects of the stimuli in order to grasp the general concepts under which the stimuli are organized. However, Hollenberg's general results did not apply to her 9-year-old subjects, all of whom were equally successful at the concept attainment tasks. Why were the 9-year-old high imagers able to overcome perceptual interference?

It could be argued that the internalization of verbal process (verbal mediation) is a major transition in development, which demands a concentrated focus on conceptual skills. High dependence on imagery may compete with conceptual activities during their acquisition, thus accounting for the lower performance of Hollenberg's 6- to 8-year old high imagers. But when the concentrated effort is over and basic conceptual skills are consolidated, imagery will no longer compete; rather, the processes will be integrated and the high imager, having the extra help of visual skills, may even excel over the low imager on tasks which both have mastered.

The present study was an attempt to test this idea in relation to Piaget's developmental stages. Hollenberg's (1970) general approach was followed, using the same measures of visual imagery. Two major variations were, first, that the age range was increased to include subjects up to 15 years of age, and second, that instead of concept attainment problems, three of Piaget's cognitive tasks were used.

The hypotheses evolved from the idea that there are certain developmental periods during which acquisition of new cognitive skills is the major activity, and other periods during which consolidation of previously learned skills is paramount. The main hypothesis was that during "acquisition" periods high imagery will be a disadvantage, because it will interfere with new learning, but that during "consolidation" periods imagery will be an asset, augmenting other cognitive activities.

Piaget's (1950) major stages of concrete and formal operations begin to emerge at 5-6 years and 11-12 years, respectively, and are generally well-established about two or three years later. During the transitions mental structures are in a state of disequilibrium and change. For purposes of this study, periods of acquisition and consolidation were represented by the following groups:

Grade One (6 years): acquisition of concrete operations

Grade Four (9 years): consolidation of concrete operations

Grade Six (11 years): acquisition of formal operations

Grade Ten (15 years): consolidation of formal operations

The first hypothesis was that in Grades One and Six low imagers would perform better than high imagers on Piaget tasks, but that in Grades Four and Ten high imagers high imagers would excel at the tasks.

A second hypothesis was based on the assumption that high visual imagery can be an asset on certain cognitive tasks throughout all developmental periods. The "mountains" task, devised by Piaget and Inhelder (1956) to measure the development of perspective coordination or "spatial egocentrism," is not considered a measure of perceptual ability but rather as an elaboration of the use of concrete operations. Although there is no question that some operational skills are needed to succeed on such spatial egocentrism tasks, the hypothesis was that visual imagery plays a major role. It was predicted that high imagers of all ages would do better than low imagers on this task.

Method

Subjects

Subjects were pupils in the public schools in Albany, California, a predominantly white lower middle-class community in the San Francisco Bay Area. Imagery tests were given to all pupils in two classrooms each in Grades One, Four, Six and Ten, a total of 249

subjects. From this sample 25 boys and 25 girls from each grade were randomly selected for individual testing on the Piaget tasks. Pupil absence reduced the final sample size to 195. For each grade, the number of subjects and average age were: Grade One, 50 subjects, 6 years 7 months; Grade Four,.47 subjects, 9 years 7 months; Grade Six, 48 subjects, 11 years 7 months; Grade Ten, 50 subjects, 15 years 8 months.

Materials

Imagery tests. Following Hollenberg (1970), four tests of imagery were used: the space subtest from the SRA Primary Abilities tes; the space subtest from the Hijlmann-Finch Test; 20 items from the Revised Minnesota Paper Form Board; and the Space Thinking (Flags) test. These tests were adapted from the set derived from Barratt (1953), who combined self-report of imagery with factor analysis to identify tests on which high scores relate to high use of imagery.

Operational tasks. Two formal operational tasks were used. The first was Displacement, devised by Tuddenham (1971) based on Piaget (1951). The task involves immersing cylinders of different sizes and materials into water and making predictions about the amount of idsplacement on each trial. The problem is to discover through the trials that the water level is determined by volume only, and not by weight. Children at early cognitive stages tend to

assume that weight is the salient factor, even when confronted with counterevidence. As development proceeds the evidence will have an increasing effect on judgments until, at the stage of formal operations, one can generalize from early trials and make correct estimates throughout the rest of the task.

The second task was the Pendulum (Inhelder and Piaget, 1958), for which the apparatus is a simple pendulum device with four interchangeable weights. The workings of the pendulum are demonstrated to the subject, who then experiments to discover which factors affect the "speed" of the pendulum (frequency of oscillation). Young children tend to focus on their own actions and will assert that pushing it harder makes it go faster. At later stages other factors are recognized, but the child is unable to separate or control for them. At the stage of formal operations the subject can control and exclude ineffective factors to isolate the single effective one (length of string).

Spatial egocentrism task. Piaget's "mountains" task (Piaget and Inhelder, 1956) was used, in the version by Tuddenham (1971) called Perspectives. The subject is presented with a three-dimensional display of a house, shed, cow and tree. A small doll is placed at various locations around the display, and at each placement of the doll the subject is to choose from a set of photographs the one which represents what the doll sees. A young subject tends

to choose the photograph representing his/her own view of the display, regardless of where the doll is. This "egocentrism" decreases with age until about nine years, according to Piaget, when most children can coordinate perspectives and succeed at this task.

Procedure

The imagery tests were administered in the classroom to the total sample of 249 subjects, using time limits. For Grades One and Four two 30-minute sessions were used, and for Grades Six and Ten all tests were given in one 45-minute session. The experimenter was introduced as someone who is interested in finding out how people think, and the non-evaluative nature of the sessions was stressed.

Two months after the imagery testing the 195 randomly selected subjects were tested individually in 30- to 45-minute sessions. Subjects were taken from the classroom in an order to suit the teacher's convenience, and were given the Piaget tasks in the same order: Displacement, Pendulum and Perspectives. There were no time limits and each subject was encouraged to take as much time as needed for each task.

To control for school achievement, available measures were obtained from the schools: teacher ratings (high, average and low) for Grades One, Four and Six; percentile scores on the Comprehensive Test of Basic Skills for Grades Four and Six; Lorge-Thorndike I.Q. scores for Grade Six; and current grade point averages for Grade Ten.

Scoring

For all imagery tests except Flags the raw score consisted of the number of correct items. For the Flags test the raw score was the number of items right minus the number of items wrong among completed items. Within each grade, test scores for each subject were standardized, based on the entire initial sample, and these scores were combined into a composite standardized imagery score for each subject. For Grade One, the Flags score was omitted from the composite scores because over one-half of the subjects scored below chance, indicating that the test was inappropriate for that age group.

The score for Displacement was the number of correct judgments, with a possible score of 11. On the Pendulum, developmental level was determined by the experimenter on a scale of 1-12, following guidelines from Inhelder and Piaget (1958) and Kuhn et al. (Note 1). A skilled independent rater scored 20% of the protocols, for which the inter-rater reliability r of .89. The score for Perspectives was the number of correct judgments, with a possible score of 8.

Results

A correlational analysis and two analyses of variance yielded results which, in general, showed a relationship between Imagery and the Piaget tasks for Grades Four and Ten, and a relationship between Imagery and Perspectives for all grades.

For Grades Four and Ten (consolidation periods) all three Piaget tasks were highly correlated with Imagery at significance levels of $p<.01$ or better. For Grades One and Six (acquisition periods) only Perspectives was significantly correlated with Imagery ($p<.05$, and $p<.01$, respectively). There were significant correlations between Imagery and sex for Grades Four and Ten ($p<.05$), and this difference, which favored the boys, was confirmed by t tests. Except for one zero correlation in Grade One, intercorrelations between the three Piaget tasks were moderately high (ranging from $r = .20$ to $r = .61$) and all but two were significant at the $p<.05$ level.

Using the school achievement measures as covariates, an analysis of covariance by Imagery (high, medium, low) was performed for each grade (Table 1). Predictive relationships between Imagery and the Piaget tasks were indicated only for Grades Four and Ten, and in those grades significant F values were reached only for Displacement and Perspectives.

In order to clarify the analysis, cell means were plotted (Fugure 1). It is apparent that in all grades the relationship between Imagery and Perspectives was in a positive direction, although this effect was significant only for Grades Four and Ten. On the other two Piaget tasks, Displacement and Pendulum, the relationships to Imagery appear weak or U-shaped for Grades One and Six,

while the relationships are in a consistently positive direction for Grades Four and Ten.

Insert Table 1 and Figure 1 about here

A second analysis of covariance for each grade, by Imagery and Sex, drew subjects from each sex separately for each imagery level, so the sample was smaller and somewhat different in composition from the original sample.

As in the previous analysis, the ability to predict performance on the Piaget tasks from imagery level was shown only for Grades Four and Ten, but in this case significant F values were fewer: for Perspectives in both grades, $F(2,28) = 3.92$, $p<.03$, and $F(2,29) = 3.28$, $p<.05$, respectively; and for Displacement in Grade Ten, $F(2,29) = 4.36$, $p<.02$.

Sex had an effect on the Pendulum Task in Grade Four, $F(1,28) = 4.36$, $p<.05$, and a strong effect on Displacement and Perspectives in Grade Ten, $F(1,29) = 17.09$, $p<.0003$, and $F(1,29) = 13.68$, $p<.001$, respectively. An analysis of cell means again showed pattern differences between acquisition and consolidation periods.

The only interaction effects of Imagery X Sex were found for Grade Ten on Pendulum, $F(2,29) = 3.32$, $p<.05$, and on Perspectives, $F(2,29) = 4.29$, $p<.02$, on which the girls' scores showed a strong

positive relationship to imagery. This result led to an examination of cell means across grades on Perspectives (Figure 2) which shows a trend for Imagery to discriminate increasingly for girls and decreasingly for boys.

Insert Figure 2 about here

Discussion

The first hypothesis involved two predictions, only one of which was supported. The results showed no evidence at any age that high imagery is an asset during consolidation periods.

All analyses showed some positive relationships between imagery and the operational tasks in consolidation periods (Grades Four and Ten), and the lack of such relationships in acquisition periods (Grades One and Six).

The correlational analysis provided the strongest evidence for a contrast between acquisition and consolidation periods. In the analyses of covariance this contrast was apparent, but was not always supported by significant F values, especially when the groups were divided by sex. These weaker effects may be due, at least in part, to the reduced sample size used in the Imagery X Sex analysis.

It would appear that high imagery does not limit Piaget task performance at any stage of development, and that it may be a real

asset during consolidation periods. These results differ from Hollenberg's (1970), in that she found high imagery to be a handicap in concept attainment tasks. This may be due to the difference in the tasks used in the two studies, but also may be the result of the different age groups involved. Hollenberg's younger subjects were in what has been designated here as an acquisition period, and among her 9-year-old subjects high and low imagers were equally successful; including older subjects might have changed the picture.

The second hypothesis predicted that high imagery would be associated with superior performance on a "spatial egocentrism" task at all ages. The results supported this hypothesis, in that the correlations between Perspectives and Imagery were positive and significant for all grades. However, the moderately high intercorrelations between the three Piaget tasks do not support the idea that Perspectives is a distinctly different task.

The analyses of covariance again provided weaker support for the hypothesis. A significant predictive relationship between Imagery and Perspectives was found only for Grades Four and Ten. However, the consistent positive-appearing relationship between Perspectives and Imagery for all grades in the graphs of cell means suggests that imagery may play a special role in the performance of this task.

An intriguing trend was found in the relationship between

Perspectives and Imagery by Sex: the cell mean patterns suggest that imagery may become increasingly salient for girls, and decreasingly salient for boys, as cognitive development proceeds. It would be valuable to investigate the possibility of sex differences in the utilization of visual imagery.

This study is more suggestive than definitive. Longitudinal research, in which subjects' relative cognitive stage progress could be more accurately assessed and followed over time, would provide clearer indications of the relationship between visual imagery and operational development. However, this study has supported the view that visual imagery plays an important role, and the distinction made here between acquisition and consolidation periods may prove to be useful.

Although Piaget continues to assert that an image is not a cognition (Piaget and Inhelder, 1971), he states that "the image proves to be indispensible for a representational reconstitution of movements and transformations already known and possibly well known to the subject" (p. 389). This and other discussions (e.g., Inhelder, 1976) support the direction of this study, in considering imagery to be facilitative in cognitive development. It is becoming increasingly clear that the nature of imagery itself is complex (Piaget and Inhelder, 1971; Webb, 1974), and that its precise relationship to operational thought is not a simple one (Anooshian and

Carlson, 1973; Brainerd and Vanden Heuvel, 1974; Rosenthal, 1975; Dean, 1976, 1979).

Reference Note

1. Kuhn, D., Langer, J., Kohlberg, L., and Haan, N. S. The development of formal operations in logical moral judgment. Unpublished manuscript, University of California, Berkeley, 1971.

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Table 1

F Values for Analysis of Covariance of

Piaget Tasks by Imagery Level

Grade One	d.f. = 2/32	One covariate eliminated	
		Univariate F	p<
Displacement		.08	.92
Pendulum		.83	.44
Perspectives		1.66	.21
Association between variables and covariates		6.42	.002
Grade Four	**d.f. = 2/31**	**Two covariates eliminated**	
		Univariate F	p<
Displacement		5.01	.01
Pendulum		2.90	.07
Perspectives		7.32	.003
Association between variables and covariates		1.22	.31
Grade Six	**d.f. - 2/30**	**Three covariates eliminated**	
		Univariate F	p<
Displacement		2.62	.09
Pendulum		1.20	.31
Perspectives		.45	.64

Association between variables and covariates	1.69	.11

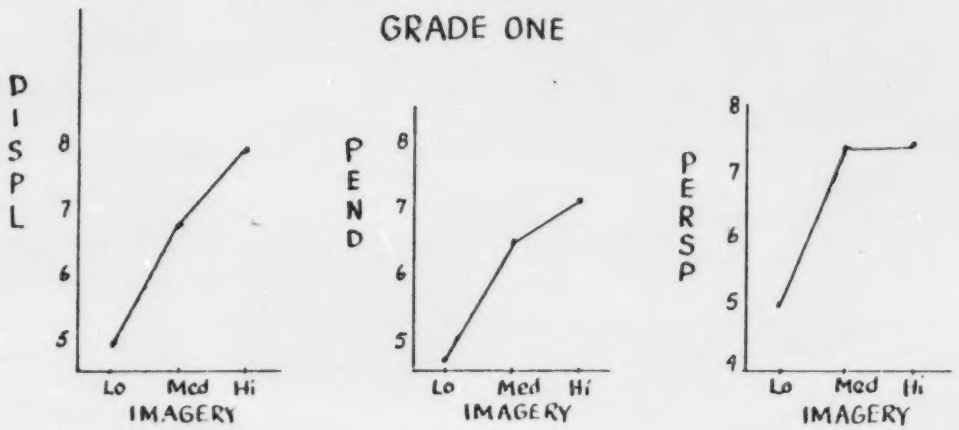
Grade Ten	d.f. - 2/32	One covariate eliminated	
		Univariate F	p<
Displacement		8.88	.0009
Pendulum		3.07	.06
Perspectives		6.19	.005
Association between variables and covariates		1.08	.37

Figure Captions

Figure 1. Mean scores on Piaget tasks by imagery level (from analysis of covariance by Imagery).

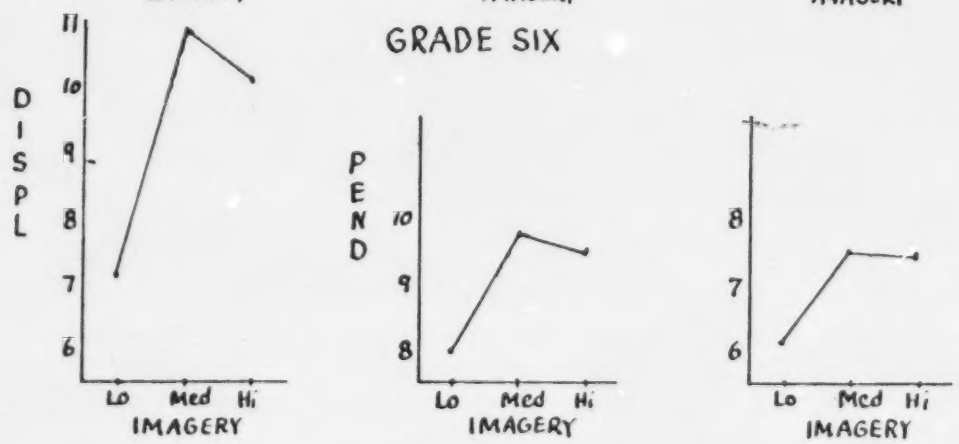
Figure 2. Mean scores on Perspectives by sex and imagery level (from analysis of covariance by Imagery and Sex).

GRADE ONE

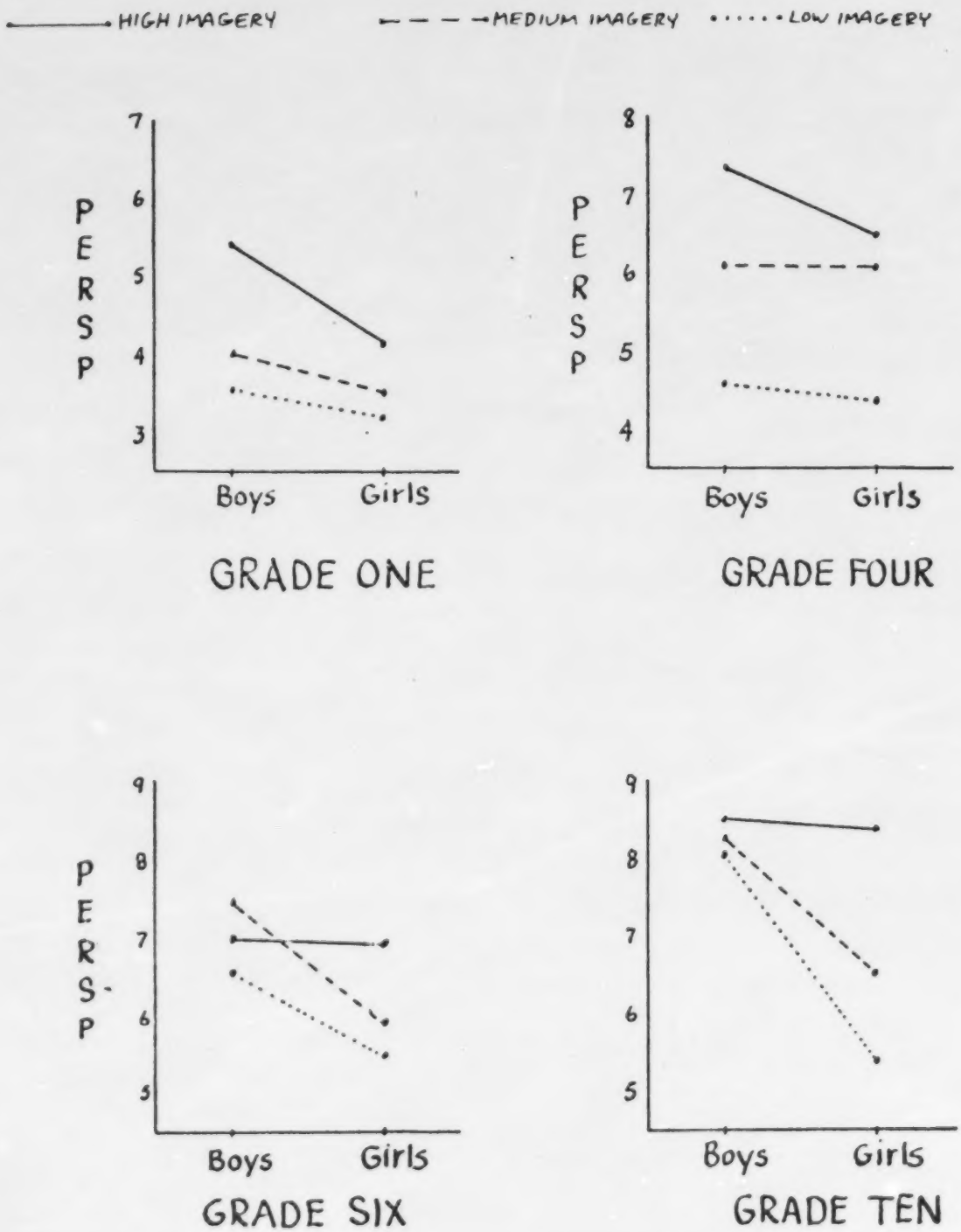


GRADE FOUR

GRADE SIX



GRADE TEN


HIGH IMAGERY
MEDIUM IMAGERY
LOW IMAGERY
PERSP
7
6
5
4
3
Boys
Girls
GRADE ONE
PERSP
8
7
6
5
4
Boys
Girls
GRADE FOUR
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GRADE SIX
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Boys
Girls
GRADE TEN